Contents

1. Purpose/Scope

This document describes a field procedure for usage of the International Light IL-1400A Radiometer/Photometer to measure light levels. The goal of this SOP is to provide a uniform methodology to

- determine light intensity levels in natural and artificial ambient light to verify adequate lighting for work operations and egress and
- determine light irradiance to measure UV, Visible, and IR light for compliance purposes with ACGIH TLVs.

2.0 Responsibilities

2.1 This program is implemented through the SHSD Industrial Hygiene Group.

2.2 Members of the SHSD Industrial Hygiene Group can qualify to perform tasks in this program. Personnel, who have demonstrated competency in performing tasks in accordance with Section 7 of this procedure, will be qualified to serve as a *Qualified Sampler.*

2.3 Hazard Analysis of the Monitoring Task: It is the responsibility of the *Qualified Sampler* and his/her supervisor to ensure that training is current and the appropriate personal protective equipment is worn. In addition, the person performing this procedure and his/her supervisor are responsible to ensure that all required training

and qualification for hazards that may be present in areas where this procedure will be used (such as respiratory protection or radiation contamination) have been met. The *Qualified Sampler* and his/her line supervisor are responsible to comply with all work planning and work permit system requirements.

2.4 Log In/Out: The *Qualified Sampler* will complete the sign in/out log in the IH equipment room prior to and after each daily use. The instrument is to be returned to the IH equipment room at the end of each days use.

3.0 Definitions

Actinic: the characteristic of radiation that indicates its capability to produce chemical change. The term is usually used with reference to UV radiation and its effects on biological systems.

Ambient Light: the light diffused in the environment surrounding a detector measuring the optical radiation from another source. This light contributes to the signal measured from the source. To make valid measurements, the contribution from the ambient light or background must be subtracted from each measurement.

Qualified Sampler: A person who has demonstrated competency, in accordance with Section 7, to perform this field procedure.

Footcandle (fc): a unit of measurement of illuminance (how much light is striking a point on a surface). One footcandle is equivalent to 10.764 lux.

Infrared (IR): the invisible portion of the electromagnetic spectrum that extends from 0.75 microns to 1000 microns. Radiation in the near infrared (NIR) produces the sensation of heat.

Inverse Square Law: correlates the relative intensity at varying distances from a point source. The relative intensity will diminish to a factor of the square root of the difference in distance. For example if at 2 meters from a source the intensity is 16 W/m^2, it will be $4W/m^2$ at 4meters. For extended (non-point) sources the intensity fall off approaches the inverse square law at a distance equivalent to 5 times the diameter of the source.

Illuminance: is a measurement of photometric flux per unit area, or visible flux density. It is typically expressed in lux (lumens per square meter) or foot-candles (lumens per square foot).

Irradiance: a measure of radiometric flux per unit area, or flux density. Irradiance is typically expressed in W/cm2.

Photopic: a sensor having sensitivity characteristic similar to the human eye response. A photopic filter will have a band pass between 400 and 700nm with its highest transmission at 550nm.

UV (ultraviolet): the invisible portion of the electromagnetic spectrum with wavelengths between 1nm and 400nm.

UVA: the portion of the UV spectrum covering the wavelength range between 320nm and 400nm. This spectral region is used for many medical, UV curing and photolithographic applications. The earth's atmosphere (at sea level) absorbs all wavelengths shorter than UVA. Prolonged exposure to UVA radiation will cause sunburn.

UVB: the portion of the UV spectrum that covers the wavelength range between 280nm and 320nm. UVB radiation is typically used in UV curing and photolithographic applications as well as in certain medical applications. Exposure to UVB radiation (from lamps or electric arcs) can cause severe sunburn and cause eye damage.

UVC: the portion of the UV spectrum that extends from 190nm to 280nm. UVC is usually employed in water treatment and sterilization applications. UVC is also used in UV curing and photolithography in microelectronics applications. Exposure to UVC radiation (from lamps, arcs, or lasers) can cause severe biological damage.

VUV (vacuum ultraviolet): the portion of the UV spectrum below 190 nm. Electromagnetic radiation below 190nm is absorbed by oxygen in air. Physical or chemical interactions requiring VUV radiation must be performed in a nitrogen purged environment down to 160nm or in a vacuum chamber below 160nm.

Visible Spectrum (VIS): the portion of the spectrum extends between 400nm and 700nm (per the CIE). It covers the wavelengths of light that the human eye can perceive.

4.0 Prerequisites

4.1 **Qualification:** The user must be qualified as per requirements in Section 7.

5.0 Precautions

5.1 **Hazard Assessment:** For all work done under this SOP there shall be a hazard assessment to determine the inherent hazardous conditions, evaluate the degree of hazard to individuals and put in place appropriate protective measures based on the hierarchy of controls.

5.2 **Work Planning:** All requirements of work permits and work planning system reviews must be met in performing this procedure.

5.3 **Waste Disposal/Pollution Prevention:** This procedure does not generate waste or result in environmental degradation.

5.4 **Personal Protective Equipment:** This meter does not require PPE. Appropriate personal protective equipment to protect the person collecting the sample must be used for areas entered for testing.

6.0 Procedure

6.1 **Equipment**

6.1.1 Radiometer/Photometer: International Light (model # IL1400A)

6.1.2 4 AA batteries(1.5 volts).

6.1.3 Detectors

6.2 A detector must be plugged in when the IL 400A is first turned on. The available detectors are:

Detector Body	Filter	Spectrum
SEL240	**T2ACT5** # 26739	**UV- Actinic** (190 to 400 nm, 700 nW/cm2 to 2.0 mW/cm2)
SEL240	W# 11547 **NS254** #27738	**UVB** 240 to 280 nm, peak response 254 nm Mercury Line Detector Head (UV 249-259 nm, 100 nW/cm2 to 350 mW/cm2).

Detector Body	Filter	Spectrum
SEL033	TD # 27876 UVA # 27531	**UVA** 310 -395 nm, peak response at 355 nm
SEL033	TD # 27876 SCS 395 # 28135 R# 859	**Blue light Hazard** 355 nm – 550 nm, peak at 425 nm
SGL 110	none	**Visible Light** 450-700 nm, peak response at 550 nm
SEL007	W# 11535	**Infrared** 850 – 1625 nm
SEL 240	none	**Laser** 325 – 1000 nm

6.3 **Turning On:** Press the "ON/OFF" button. No warm up of equipment needed.

6.4 Buttons on the meter:
"ON/OFF": powers unit on and off.
"SIGNAL": selects the continuous monitoring of a constant light source.
"INTEGRATE": selects the integration mode ("HI INTEG" or "LO INTEG" that was last use. "INTEGRATE" mode automatically calculates he ongoing accumulated dose in Joules/cm2. Press 'HOLD' to terminate or pause the integration. If 'HOLD' is pressed a second time, the instrument will unfreeze the display and return to the uninterrupted integration allowing intermediate readings to be taken.
"ZERO": causes the instrument to cancel the present reading of the zero and assign the current light level to zero.
"HOLD": temporarily freezes the display to hold a reading for convenience when measuring in a darkroom or in similar situations where it may be inconvenient to read the display in a 'SIGNAL' mode.

6.5 If the 'Bat Lo' message displays and stays on, batteries must be changed. Four new alkaline batteries will last up to 54 hours.

6.6 **Zero the meter:** Failure to check the zero is the biggest cause for erroneous readings because the last stored zero is retained. To test zero, cover the sensor. The reading should go to zero. To re-set the zero, cover the detector or source being measured and press the zero button.

6.7 **Calibration:** There is no field calibration that can be done at BNL. The manufacturer calibrates this equipment.

- For general ambient light measurements, the meter does not need to be calibrated.
- For measurement of compliance with ACGIH TLVs for Illumination, the meter needs to be calibrated within 12 months.

6.5 **Taking Readings:**

6.5.1 **For Illuminance:** Place detector where you want the light intensity to be read. The detectors sensor should be on the same plane as the surface to the measured. For example: to measure the light on a step of stairs, place the probe face up on the tread of the stairs, do not point the probe at the stairs from eye level. The meter automatically adjusts to the units to the probe selected. It will automatically have the reading on screen of IL1400A.

6.5.2 **For Irradiance:** consult the instrument manual for the meter probe placement specific to the source characteristics.

6.6 If the incoming light exceeds the maximum range of the detector, the display will blink "OVR RNG" and "++++++++++".

6.7 **Power off:** press the "on/Off" button. Note: the IL-1400A will autoshut off after 10 minutes.

7.0 Implementation and Training

7.1.1 **Qualification Criteria:** For all BNL personnel, the qualification criteria to perform this procedure demonstration of proper use of, and interpretation of results using ***Attachment 9.2.*** Personnel shall be re-qualified at a frequency not to exceed three years, provided there is no break in the work assignment that utilizes this procedure. If significant and substantive changes to the procedure are made, *Qualified Sampler*s will be notified of the changes.

BROOKHAVEN NATIONAL LABORATORY Safety & Health Services Division INDUSTRIAL HYGIENE GROUP Standard Operating Procedure: Field Procedure	NUMBER **IH94500** REVISION **Final Rev0**
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8.0 References

8.1 International Light Operating Manual for the IL-1400a Radiometer/Photometer.

8.2 A. D. Ryer: International Light: The Light Measurement Handbook, 1997

9.0 Attachments

9.1 Theory of Operation

9.2 Job Performance Measure

10.0 Documentation

Document Development and Revision Control Tracking		
PREPARED BY: *(Signature and date on file)* A. Laforest SUNY-SB Intern Date 05/07/06	REVIEWED BY: *(Signature and date on file)* C. Weilandics CIH, SHSD IH Group Date 05/09/06	APPROVED BY: *(Signature and date on file)* R. Selvey SHSD IH Group Leader Date 05/09/06
ESH Coordinator/ Date: *none*	Work Coordinator/ Date: *none*	SHSD Manager / Date *none*
QA Representative / Date: *none*	Training Coordinator / Date: *none*	Filing Code: **IH52**
Facility Support Rep. / Date: *none*	Environ. Compliance Rep. / Date: *none*	Effective Date: **05/09/06**
ISM Review - Hazard Categorization ☐ High ☐ Moderate ☒ Low/Skill of the craft	Validation: ☐ Formal Walkthrough ☐ Desk Top Review ☐ SME Review Name / Date:	Implementation: Training Completed: Tracked in BTMS Procedure posted on Web: 05/09/06 Hard Copy files updated: 05/09/06

Revision Log		
Purpose: ☐ Temporary Change ☐ Change in Scope ☐ Periodic review ☐ Clarify/enhance procedural controls Changed resulting from: ☐ Environmental impacts ☐ Federal, State and/or Local requirements ☐ Corrective/preventive actions to non-conformances ☐ none of the above Section/page and Description of change:		
(Signature on file) SME Reviewer/Date:	Reviewer/Date:	Reviewer/Date:

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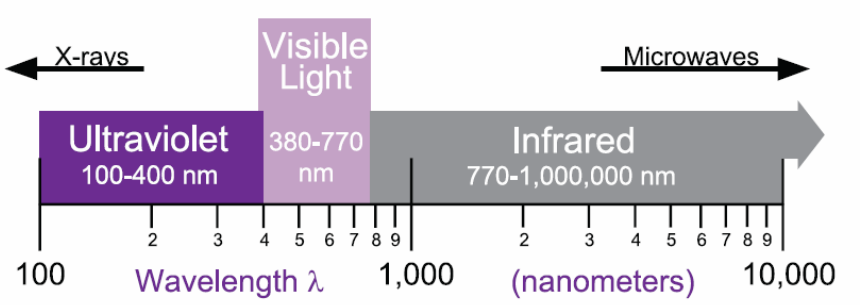
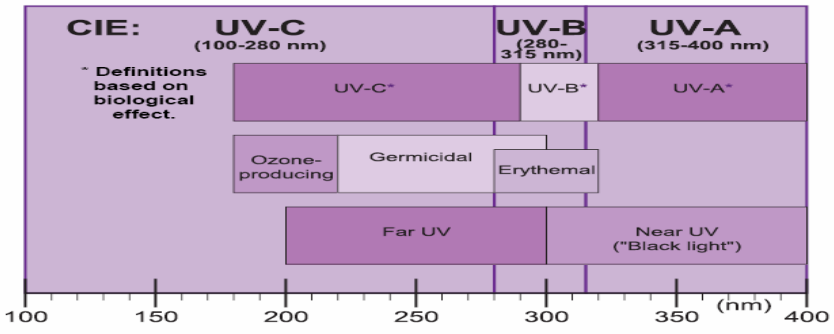
Attachment 9.1
Theory of Operation

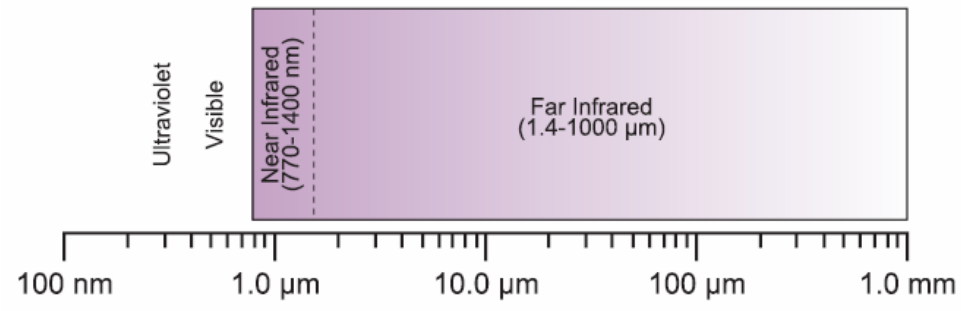
The Spectrum of Light



The Ultraviolet Spectrum



The Infrared Spectrum



There are two sets of standards, each with their own units, which apply to the measurement of optical radiation. They are the photometric and the radiometric standards. Photometric standards and units are based upon the spectral response of the human eye and should only be used in applications involving illumination and human vision. By definition, these units can only be applied to the visible portion of the spectrum (400-700 nm). All applications other than vision and illumination, including all applications in the ultraviolet and infrared, require the use of radiometric units.

Optical Radiation Hazards

Application	Common Sources	ACGIH Spectral Range	IL Measurement Range	Units
OPTICAL RADIATION HAZARD Unprotected skin and eye hazard	Welding	**180-400 nm ***	$5.00e^{-9}$ to $2.50e^{-3}$	eff W/cm²
	Office light, copier		$1.49e^{-7}$ to $1.49e^{-3}$	eff W/cm²
XERODERMA PIGMENTOSUM Extreme sensitivity to any light source	Emmiting any	**250-400 nm ***	$2.33e^{-9}$ to $2.33e^{+0}$	W/cm²
	UV light		$1.82e^{-7}$ to $6.36e^{-1}$	W/cm²
BLUE "EYE" HAZARD Retinal Photochemical Protection	Welding	**305-700 nm ***	Customized spectrum	W/m²/nm
	Solar light		$7.41e^{-10}$ to $7.41e^{-1}$	W/cm²
	High powered VIS		$5.56e^{-9}$ to $5.56e^{+0}$	W/cm²/sr
	Manufacturing		$3.70e^{-8}$ to $1.30e^{-1}$	W/cm²
	Lasers		$2.78e^{-7}$ to $9.72e^{-1}$	W/cm²/sr
IR-A NEAR IR Retinal protection protocol	IR heat sources	**770-1400 nm ***		
	Manufacturing		$7.14e^{-11}$ to $7.14e^{-2}$	W/cm²
	Lasers		$3.57e^{-9}$ to $1.25e^{-2}$	W/cm²
IR HAZARD Cornea thermal injury	IR heat sources			
	Manufacturing	**770-3000 nm ***	$8.57e^{-5}$ to $9.52e^{-1}$	W/cm²
	Lasers		$8.57e^{-5}$ to $4.14e^{-1}$	W/cm²

International Light Web page from American Conference of Governmental Industrial Hygienist (ACGIH®), 2004 TLVs® and BEIs® Book.

BROOKHAVEN NATIONAL LABORATORY

IH94500 Attachment 9.2

HP-IHP-94500

Environmental, Safety, Health & Quality Directorate
SHSD Industrial Hygiene

IL 1400 Meter- Qualified Sampler
Job Performance Measure (JPM) Completion Certificate

Candidate's Name	**Life Number:**

Knowledge of the Principles of the Hazard and the Method

Criteria	**Qualifying Standard**	Unsatis-factory	Recov-ered	Satisf-.actory
Hazard Analysis	Understands the need to perform a hazard analysis of the sampling area and potential exposure to the sampler.			
Personal Protective Equipment	Understands the need to be aware of the potential lead contamination to sampler and knows how to determine the need for PPE.			
Sampling Protocol	Understands the exposure monitoring logic necessary to appropriately select sampling locations to accurately measure worker, public and environmental exposure potential.			
Analysis of data	Understands the need to perform analysis on the sampling data to assess potential exposure to the sampler, worker, public and environment, and to recommend corrective actions as necessary, and employee notification.			

Practical Skill Evaluation: Demonstration of Field Methodology

Criteria	**Qualifying Performance Standard**	Unsatis-factory	Recov-ered	Satisf-.actory
Sampling Equipment	Knows where equipment needed for the procedure is located and how to properly sign it out.			
Preparation of the meter	Understands the importance of checking the calibration of the meter prior to and at the end of use.			
Selection of Probe	Demonstrates knowledge of the range and wavelength of the various probes			
Placement of Meter	Demonstrates the proper placement of the meter on surfaces for testing.			
Sampling Repetition	Understands the importance of multiple readings at each location and multiple similar locations to obtain confidence in the readings.			
Record forms	Shows how to correctly and completely fill all forms associated with this SOP.			
Data Analysis	Shows how to correctly have the data analyzed and compared to occupational exposure limits and surface limits.			
Employee Notification	Knows how to timely and properly notify workers and management of over exposure or contaminated surfaces.			

Employee: I accept the responsibility for performing this task as demonstrated within this JPM and the corresponding SOP.

Candidate Signature:	**Date:**

Evaluator: I certify the candidate has satisfactorily performed each of the above listed steps and is capable of performing the task unsupervised.

Evaluator Signature:	**Date:**